SURVEY OF UAV APPLICATIONS IN CIVIL MARKETS (June 2001)

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Abstract--A summary of UAV systems, history of evolution, military successes, and applications to civil markets, as well as future trends is presented. Findings justify current major efforts worldwide towards better design, autonomous navigation and control of small, smart unmanned aerial robots for a variety of applications.

I. INTRODUCTION

During the last thirty years UAV systems have evolved into highly capable machines, used by the armed forces world wide, mostly for surveillance and data acquisition purposes. The demand for these products in the commercial industry arises from the low manufacturing and operational costs of the systems, the flexibility of the aircrafts to adjust to the particular needs of the consumer and the elimination of the risk of human lives (pilots) in difficult missions. Still, introducing this technology into a commercial marketplace is a problem associated with many difficulties since there are many reliability and airworthiness issues waiting to be solved.

The aim of this paper is to carry out a market research for the potential use of UAVs in the commercial industry, identify the risks and uncertainties associated with this challenge, and to propose solutions on how to overcome the potential problems.

II. 2. UAV SYSTEMS

A. System description

An unmanned aerial vehicle is a system comprised of three main features: the aircraft, the Ground Control Station (GCS) and the operator.

The design and performance considerations for UAV aircrafts have emerged from the existing body of knowledge of modern aviation. However UAV designers do not have to take into consideration the presence of the human factor on board. This gives UAVs the advantage of reduced drag due to the elimination of the cockpit and the reduced weight (of the pilot and other systems), as well as the ability to sustain a greater amount of g-forces. One of the most important features of a UAV platform is the payload they can carry. These payloads can be high and low resolution cameras/video cameras, day and night reconnaissance equipment, warfare machinery (ESM, ECM, ECCM), and generally any equipment required for the mission the UAV is designed for.

An area where UAVs have developed their own technology is that of telecommunications, guidance and control technology. Improvements in miniature solid-state gyros and sensors have made the platforms more reliable in terms of flight control. Modern telecommunication technology can uplink flight and mission commands to the aircraft at very long rates and over large distances [1].

There is a big debate in the industry, whether UAVs should be operated by pilots or by operators. This may be a crucial point for the future of unmanned aerial vehicles in the civil industry, since the operator plays a significant role in attaining UAV flight certification from the Civil Aviation Authority (CAA). It is important to note that although the human factor is removed from the cockpit he is not removed from the mission [2].

B. UAV classification

The European Unmanned Vehicle Association identifies five main categories of UAVs [3]:

1. **Close range**, which includes aerial vehicles that fly in a range of less than 25 km. Usually these aircraft are extremely light and can be launched by hand.
2. **Short range**, which are platforms that operate within a range of 25-100 km. Such systems are designed for operations within a limited area.
3. **Medium range**, these are UAVs able to fly within a range of 100-200 km. Aircrafts of this category are defined by a more advanced aerodynamic design and control systems due to their higher operational performance.
4. **Long range**, which are UAVs that can fly within the range of 200-500 km. As in the previous category such systems are required to use more advanced technology to carry out complex missions. Also they need a satellite link (or another platform acting as a relay) in order to overcome the communication problem between the GCS and the aircraft created by the curvature of the earth.
5. **Endurance**, which are vehicles able to operate in a range of more than 500 km, or that can stay in the air for more than 20 hrs. These are considered to be the most sophisticated of the UAV family due to their high capabilities. They can be distinguished from other systems by their large dimensions and their high capabilities.

Among the first three categories described above, we can find the Vertical Take-Off and Landing (VTOL) UAVs. These aerial platforms have the ability to take off and land vertically, as well as to hover over the ground, but they lack in range capabilities. Also a new category of UAVs that has emerged over the past few years is the Micro Air Vehicles. Micro UAVs, are tiny air vehicles with a size of no more than 15 cm of wing span and length. The development of such systems is associated with radical ideas and state of the art technologies in the fields of in-flight control, navigation, communications and propulsion. Possible applications of such systems are, surveillance, damage assessment and chemical detection inside cities and buildings.

C. History of UAVs in the military market

It is important to know the factors that have influenced the UAV industry through the years and acted as driving forces toward its current position. Those factors are: the demise of the Soviet Union, the shrinking of the defence budget in most countries and the Persian Gulf War.

The collapse of the cold war between the USA and USSR eliminated the requirements of billions of dollars to be spent for strategic intelligence and reconnaissance systems. Thus the US government (which holds most of the market of UAVs) was forced to find a more cost effective way to perform specific war-fighting tasks. Also the new world order that arose was unpredictable, not traditional and unsuitable for appraisal by the strategic intelligence system of that time [4].

Living in a global community where the deeds of one nation are affecting the political status of another, the requirements of strategically intelligent systems are becoming more and more important. The shrinking of the defence budget worldwide is a fact, too. As a result of that the armed forces are striving to find cheaper solutions for those military needs.

The last catalyst responsible for boosting the UAV industry was the lessons learned from the Gulf War. Behind the operation Desert Storm, there was an unforeseen war fought from an intelligence systems perspective.

Operations which contributed to the popularity of UAVs were also those during the War in Vietnam where the AQM-34 Lightning Bug provided the armed forces with crucial reconnaissance information. The success of the Israeli Pioneer aircraft used in the Six Day War as a decoy over the Golang Heights, and the impressive performance of the Predator UAV during the recent Balkan War have also highlighted the importance of UAVs.

D. UAVs and their Military Applications

UAVs are capable of performing a variety of missions supporting military and intelligence purposes. The list below presents the military applications that UAVs have served up to now.

1. Reconnaissance Surveillance and Target Acquisition (RSTA).
2. Surveillance for peacetime and combat Synthetic Aperture Radar (SAR).
3. Deception operations.
4. Maritime operations (Naval fire support, over the horizon targeting, anti-ship missile defence, ship classification).

5. Electronic Warfare (EW) and SIGINT (SIGnals INTelligence).
6. Special and psyops.
7. Meteorology missions.
8. Route and landing reconnaissance support.
9. Adjustment of indirect fire and Close Air Support (CAS).
10. Battle Damage Assessment (BDA).
11. Radio and data relay.

III. CIVIL UAV MARKET

A. Civil UAV applications

The potential uses of Unmanned Aerial Vehicles in the civil industry are:

1. **Border interdiction.** Patrol of the borders by aerial platforms.
2. **Search and rescue.** Looking for survivors from shipwrecks, aircraft accidents etc.
3. **Wild fire suppression.** UAVs equipped with infrared sensors can detect fire in forests and notify the fire brigade on time.
4. **Communications relay.** High altitude long endurance UAVs can be used as satellites.
5. **Law enforcement.** VTOL UAVs can take the role of police helicopters in a more cost effective way.
6. **Disaster and emergency management.** Aerial platforms with cameras can provide real time surveillance in hazardous situations such as earthquakes.
7. **Research.** Scientific research of any nature (environmental, atmospheric, archaeological, pollution etc) can be carried out by UAVs equipped with the appropriate payloads.
8. **Industrial applications.** Such applications can be crops spraying, nuclear factory surveillance, surveillance of pipelines etc.

B. Civil UAV market statu

According to a strategic research report conducted by Frost & Sullivan, the world market for UAVs will experience growth through the forecast period 1994 to 2004. The market revenues for the period of 1997 were almost $2.3 billion where as those for the period of 1998 reached almost $2.1 billion. After 2000 the market revenue growth is expected to accelerate as technological and regulatory issues are addressed [5]. More particularly the civil UAV market worldwide reached $80 million in the year of 1997 [6]. The military market revenue was $2.22 where as the revenues for the civil market were only $0.08 billion.

Despite the fact that the civil UAV market is responsible for only 3% of the total market revenue, after 2000 it is expected to expand rapidly.

According to research conducted by the defence/aerospace industry analyst Katrina Herrick, the regional market breakdown for the period of 1997 to 2004 is as follows:

TABLE 1. REGIONAL MARKET BREAKDOWN FOR PERIOD 1997 TO 2004.

REGION	MARKET PERCENTAGE (%)
EUROPE	25-30
NORTH AMERICA	35-40
PACIFIC RIM	15-25
MIDDLE EAST	10
AFRICA	5-6
OTHER	6-8

C. Target marketing for civil UAV industry

The first step towards target marketing is to prioritise the segments according to their attractiveness. In that way we can later analyse the characteristics of each segment and take competitive decisions about the products and markets [7]. Carrying out a Pareto analysis will derive the segment attractiveness with results as shown in Table 2.

TABLE 2. PARETO TABLE FOR CIVIL UAV INDUSTRY FOR THE YEAR 1997.

REGION	RE/NUE ($ million)	CUM/VE RANGE	CUM/VE RE/NUE ($ million)	CUM/VE RANGE (in %)	CUM/VE RE/NUE (in %)
N. AMERICA	28	1	28	17	35
EUROPE	20	2	48	33	60
PASIFIC RIM	12	3	60	50	75
MID. EAST	8	4	68	67	85
OTHER	6.4	5	74.4	83	93
AFRICA	4.8	6	79.2	100	99*

It is clear that North America and Europe are by far the largest markets for the civil UAV industry today. More specifically those two countries are responsible for 60% of the total market revenue. The reasons behind the fact that North America and Europe are the two dominant forces in the civil UAV market, lay behind the technological superiority and long UAV history of those two regions.

Most of the UAV manufacturers and suppliers come from those two regions, thus it is logical that industries from North America and Europe, encouraged by their Governments and Armed Forces, are the first to see the potentials and applications of such systems. It would be fare to characterize the North American and European industries as highly competitive forces in the civil UAV market. Any breakthrough at UAV technology is first developed and tested in USA and Europe and if it is successful it moves on to the rest of the world. Thus those two regions are naturally the market leaders whereas other countries are the market followers.

IV. INDUSTRY ANALYSIS

A. Forces governing the industry

The aim of this section is to present the current industry environment that UAV companies are operating. The best way of achieving this is by using Porter's five forces model, represented in Figure 1 and explained in the sequel.

1. In the first force, emphasis is given in the number and the strength of the competitive firms, the rate of industry growth, the capacity available and the exit barriers.
2. The second force determines whether or not it is easy for an alien firm to enter the current market.
3. The third force measures the ability of the customers to suppress the market.
4. The fourth force, considers our ability as suppliers to suppress the market to our benefit
5. Finally the last force analyses the threat of the substitutes.

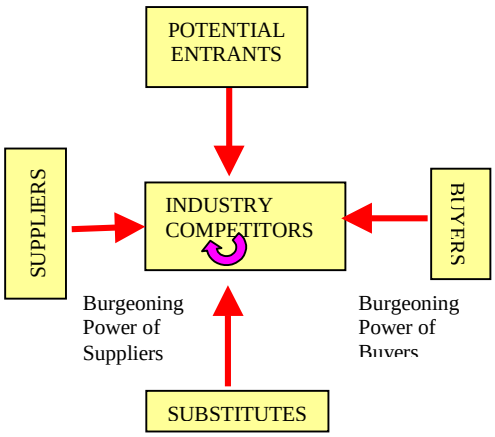

Fig. 1. Porter's five forces [8]

B. Industry competitors

Looking at the on-going projects in the military UAV industry today, we can identify more than 100 companies with each of them having a variety of products corresponding to different market requirements. It would not be an exaggeration to say that almost all of them are planning to enter or have already entered the civil market. This will result in an increasingly competitive market and the number of manufacturers will be forced to decline.

The overall level of profitability in an industry is influenced significantly by the nature and rivalry that exists among the firms in the industry. Thus industries with little competition tend to be more profitable than industries with intense competition. Similarly profitability tends to be higher in industries where competition is based on innovation than in industries in which it is based on price [9]. The industry of our interest is highly competitive thus it would not be expected to be very profitable. This is not the case though since we ignored the changes in basic technology, a factor that has a tremendous impact on the success of a company in this field. It is a fact that the leading firms in the market do not relay on the innovation or cost-effectiveness of their products, but on the state of the art technology surrounding their systems.

C. Potential entrants

In order to see how easy it is for an alien firm to enter the UAV industry, we first have to examine the industry's entry and exit barriers. The barriers to entry include:

1. Absolute cost barriers, such as those afforded by patents, availability of capital

at lower costs, and access to less expensive raw materials.
2. Limited supply barriers, such as control over key raw materials supplies and limited access to distribution channels.
3. Marketing barriers, such as those possessed by the holders of strong distribution consumer franchisers.
4. Legal and/or political barriers, such as import quotas [9].

The absolute cost and limited supply barriers can be associated with large corporations in the UAV industry, who due to their larger scale of production volumes compared to other companies attain better prices and better treatment from their suppliers. They have the luxury of ordering material fitting to their individual requirements whereas others have to compromise to what is available in the market. Marketing barriers appear especially in the segment of very long range and endurance UAVs, where the loyalty of the product and the credibility of the company play a very important role.

Porter's study indicates that in some industries there are significant barriers to exit. He has shown that it is very difficult to withdraw from some industries in a profitable basis due to several structural implements [10]. Those structural implements in our case are the high capital intensity requirements. When a new company enters the market, it is required to invest money on developing the entire UAV system that it is planning to promote. Thus money for research and development has to be spent in the areas of aircraft technology, telecommunications and aircraft control station. We all know how costly R&D operations can be and especially in the area of general aviation. Also there is a high risk of uncertainty about the outcome of an R&D operation. Will the aircraft fly? If it flies, does it fly in the way the market requires? Have I achieved a competitive UAV system?

D. Buyers-Suppliers

When a company or a government organization is about to acquire a UAV system the purchasing one person does not make decision only. Instead, a comity comprising many individuals is given the responsibility of assessing the product, the company and the profitability of the purchase. One approach to understand the roles of each member of the organization in the purchasing decision process is through the "evaluation matrix" in Table 3, which is a theoretical scenario of what a customer would consider before acquiring the product from the manufacturer.

TABLE 3. "EVALUATION MATRIX" FOR A UAV SYSTEM PURCHASE.

	Evaluation Participants					
Evaluation Stages	Internal Factors				External Factors	
	Technical committee	Financial committee	Purchasing department	Operations department	Companies affected by purchase	Political guidance
Requirement Specifications	✔		✔	✔	✔	
System Evaluation	✔		✔	✔		
Manufacturer Evaluation	✔		✔			✔
System Support	✔		✔	✔	✔	
System Maintenance	✔		✔	✔	✔	
Operator Training	✔			✔		
Alternative Systems	✔	✔	✔	✔	✔	✔
Cost of System		✔	✔			
Cost of Support		✔	✔			
Cost of Maintenance		✔	✔			

As can be observed the evaluation process is not simple at all. There is a detailed study on behalf of the company and there are many bases upon which the consumer can negotiate with the manufacturer. Also another important point given by the matrix is the fact that there are external factors affecting the purchasing process. Another factor supporting the burgeoning power of the buyers is the size concentration of the purchases. The loss of a customer can have a significant impact on the company's future carrier. This is due to the nature of the industry, where the supplier/buyer ratio is very high and it would be hard for the manufacturers to find somewhere else to sell their products or services. Also the total profit of a UAV company usually comes from three or four different buyers thus a single customer contributes a large amount to the company's annual turnover.

E. Substitutes

In the civilian surveillance market, UAVs are those considered to be the substitutes. There is an existing market possessed by commercial aircraft and UAVs are the alien products trying to break in.

Unarguably manned aircraft have been performing their job well and aviation companies have established their products over the long period of time of their operation. The users know and trust the product and have no reason to look for a substitute unless there is a competitive product with reduced cost and/or superior capabilities.

The cost benefit of UAVs in the military market should first be reviewed. Most analysts believe that the cost of a UAV is less than that of a manned aircraft in the same role. This statement is strongly supported by the Defense Airborne Reconnaissance Office (DARO) which developed a performance indicator "pound hours per kilo per 1000 dollars" that indicates the cost of placing and maintaining a reconnaissance payload on station [11]. Also the cost of the latest Predator and Dark Star UAVs are $3 million and $10 million respectively [12]. Comparing the above figures to the $25 million cost of one of their manned competitors the F15 aircraft, we can see that by all means it is more cost-effective to deploy a squadron of UAVs for a military operation than a manned aircraft. We should note that new generation military aircraft are more expensive than the F15 mention above, which started being operational almost two decades ago. Also the costs of military aircraft are rising and will continue to rise in the future. For example the F-100 (year 1954) costs $2 million, the F-4 (year 1962) costs $6 million and finally the F 15 (year 1975) costs $25 million [13]. All of the aircraft mentioned above belong to the fighter aircraft family used by the military for reconnaissance operations. Hence, it is obvious how UAVs compete with manned aircraft in the military industry and we presented the reasons behind their success.

Unfortunately this is not the case in the civil market. In this segment, UAVs hold a low market share and it is very hard for them to compete with their equivalent manned on a cost-effective basis. This is due to the fact that the cost (operational and manufacturing) of manned aircraft in the civil industry is a lot cheaper than their cost in the military industry. Thus their competitive costs together with their high capabilities and the long history they possess in the civil industry make them a strong opponent difficult to defeat.

V. FUTURE TRENDS

A. Product Portfolio Matrix

To best describe the position of UAVs in the civil market today, we are using the product portfolio matrix developed by the Boston Consulting Group and given in Figure 2.

As can be seen from Figure 2, "stars" are probably the best products to have. However they require high levels of investment to ensure their continuous success. "Cash-cows" on the other hand are described by a more mature stage of product and most of the times they provide funds to stabilize their successors. Nevertheless this does not mean that they do not deserve any further investment. "Problem children" have the potential to be developed to a "cash-cow" product, but they require more investment and the appropriate strategic decisions. Finally "dogs" are problematic products that need to be reviewed regularly so that decisions can be made about when to withdraw them from the market [14].

UAVs in the military market are classified as "cash-cows". Commercial UAV products are described as "problem children" since due to several reasons their full potentials have not yet been exploited. Since most of the civil UAV companies come from the military market, it is logical to assume that at the moment many corporations invest the profit they make from several military projects to the support and development of their commercial divisions. If manufacturers want the civil UAV industry to grow, they have to invest money on the commercial aspects of their products. There is a long way ahead for a "problem child" to become a "cash-cow". Also the prosperity of the military market segment is highly associated to the development of the commercial UAV industry.

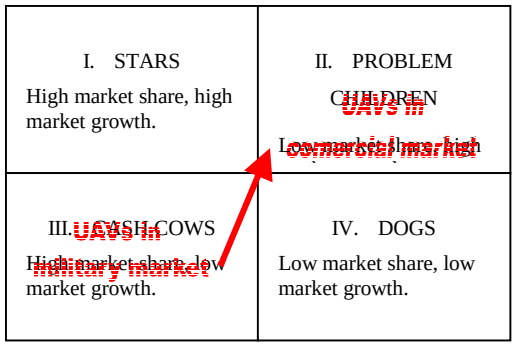

Fig. 2. Product portfolio matrix.

The red arrow shows the economical support given by the military segment to the commercial.

B. *Experience curve effects*

In many industries one of the major factors affecting the competitive business strategy, is the "experience curve effects" a term created by the Boston Consulting Group (BCG). This concept states that every time the total industry volume doubles the total constant-dollar-per-unit cost of producing, distributing and selling a particular product will decline by a constant percentage (usually 15-30%) [15]. In Figure 3 we can see that the unit-cost/industry-volume relationship is exponential.

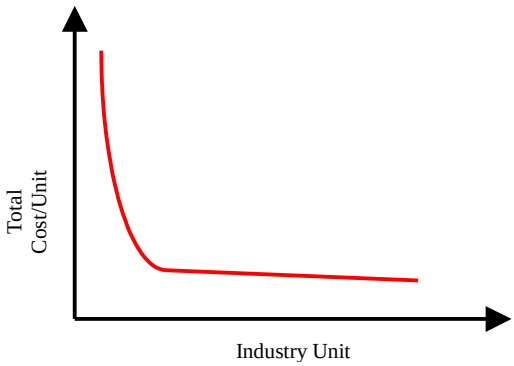

Fig. 3. Unit cost vs. industry-volume chart.

The reason for referring to this "experience curve effect" in this chapter is because this phenomenon has been observed throughout the history of the military UAV industry. The cost of the UAVs manufactured and promoted for the armed forces today, are way cheaper than the UAVs manufactured some decades ago. One of the reasons for this is the fact that over these decades more companies have entered the industry. Since the civil UAV market is still growing it would be reasonable to assume that it will follow the same pattern as the military market did. Thus the cost of manufacturing and promoting UAVs for civil application will probably reduce in the future.

VI. MARKETING THREATS & OPPORTUNITIES

A. *SWOT Matrix*

The SWOT matrix is seen as one of the best methods for identifying and analyzing the factors, which will have the most impact on the performance of a company's future career in an industry. The analysis is broken down into two main parts. The first part is concerned with the internal strengths and weaknesses of the company. At this stage we are considering factors such as the financial status, the resources, the capabilities and the competencies of the company. The second part is concerned with the external environment of the company and more specifically with the marketing threats and opportunities associated with the industry. For the purposes of this project we are only interested at the issues, which affect the industry's future progress, thus only the marketing threats and opportunities have been considered.

Trying to derive conclusions from a SWOT analysis it could some times be a tricky process. That's because we may have created a long list of factors affecting the industry, but most likely only a few of them are actually having a significant impact on it. Thus by focusing on too many issues, we are taking the risk of deriving an analysis based on things that are not really important for the industry's future. In the following table, the marketing threats and opportunities associated with the commercial UAV industry are presented. In the rest of this chapter, we will analyze the important issues of the marketing threats (highlighted yellow in Table 4) and opportunities (highlighted blue in Table 4).

TABLE 4. MARKETING THREATS AND OPPORTUNITIES FOR THE CIVIL UAV INDUSTRY.

THREATS	OPPORTUNITIES
Safety issues remaining to be solved. *A very important issue, but it cannot be analysed in this project due to its technical nature.	Increase of demand of aircraft operations in the civil industry over the last decade.
Airworthiness and certification issues from CAA.	Integration of UAVs to a more sophisticated system.
Product not known to the public.	Technological breakthroughs which wider the UAV applications.
High manufacturers/market ratio.	Government support to projects diversified from military to civil markets.
Lack of experience in the civil market.	Benefits of the military market associated to the growth of the civil UAV market.
High competition from manned aircraft.	Successful past military operations.
UAV manufacturers possessed by a military mentality.	Elimination of risk of loosing human lives in dangerous missions.
Questions about the cost-effectiveness of UAV operations in the civil market.	No need for consideration of the operator in the aerodynamic design of the aircraft.

Not a well-established industry, thus it is hard for manufacturers to attain certain parts.	No need for consideration in the performance of the aircraft for human tolerances (g-loading sustained by the pilot.).

B. Airworthiness and certification issues

When a new aircraft is designed, its safety and reliability has to be tested and certified before it reaches production. This procedure is called airworthiness, and the organization responsible for such issues is the Civil Aviation Authority (CAA) of the country of origin. Also, before the aircraft is introduced into the production stage, the manufacturer is assessed in quality issues in order to ensure that each aircraft produced will be identical. Finally, when it is sold and launched into the market, the user is forced to follow certain rules and procedures in all areas of aircraft operation (maintenance, spare parts, crew training, etc.), in order to ensure the safest possible functioning of the aircraft. All of these issues are regulated by CAAs worldwide and the Joint Aviation Authority (JAA), who publish rules and procedure manuals that every manufacturer and operator must follow. As we understand, conducting business in the general area of aviation is a process associated with many difficulties. The first concern is public safety, thus everybody has to play by the book. The manufacturers have to spend a lot of their time, money and resources in order to comply with the existing safety standards. Since it is so difficult for conventional aircrafts to be granted fit for production and operation, we can imagine how hard it would be for unconventional ones such as UAVs. Up to now, no rules and regulations have been assigned for the operation of UAVs in controlled airspace.

Bringing up the subject of airworthiness and flight certification for UAVs in controlled airspace, one may wonder how after 50 years of operation, UAVs have not yet been granted with such standards. The answer to this question is that during all of these years, UAVs have been manufactured for the armed forces, which use their own individual aviation system. In the case of military UAVs, the product has to comply with the individual standards of each customer. Sometimes these standards are different, depending on the nationality and the body of operations of each service (air force, navy, army, etc.). In the cases of the ongoing commercial UAV projects, the users either fly the aircraft in uncontrolled airspace (airspace not protected by any authority) or they attain a special permit from the airspace regulating authority. For example, to fly a UAV in the National Airspace System (NAS) in the USA, the user has to obtain a certification form the Federal Aviation Administrator (FAA). This kind of approval is given in a case-by-case basis and is granted by the region of operation. As we can see, the only organization today who is able to use UAVs to their full potential is the army. The commercial users are either unable to use them or they have to struggle in order to attain a temporary permit.

It is easy to understand why the lack of airworthiness standards is the most important problem that the commercial UAV industry is currently facing. Over the last few years, the industry has been dealing with this problem, by contacting the CAAs of various countries and by suggesting regulations that could be applied as UAV airworthiness standards. A very important effort towards this direction has been initiated by the EURO-UVS. This organization has managed to bring together members of the industry and members of the CAA in order to discuss potential solutions and future strategies that the industry should follow. This was achieved by the development of several working groups comprised by members of the industry, military and CAAs, of which their main purpose is to identify, analyze and propose solutions for the major problems that the industry is facing today. The countries the working groups are currently operating are: Austria, Belgium, Finland, France, Germany, Greece, Italy, Norway, Spain, Sweden, and Switzerland.

The most challenging task of these efforts is to manage and make the various government organizations (CAA, JAA, FAA, etc.) to get involved. What we have seen up to now is the interest shown by many individuals working for the CAAs worldwide, the FAA and the JAA, who through their proposals try to contribute to the solution of the problem. However, there have been very few signs yet that these organizations are actually concerned and are ready to take initiative.

From conversations between the industry and government officials there have been a lot of feedback data on how UAVs could be granted as fit to fly in controlled airspace. Putting aside the technical aspect of these feedbacks, the bottom line is that the reliability of UAVs has to be increased and demonstrated to the appropriate authorities. Up to now manufacturers working under military projects were putting aside the safety issues associated

to the UAV operations. This is not the case any more. If we want UAVs to be treated equally as manned aircraft, we must realize that the safety issues have to come first. This means that R&D programs have to be directed towards the improvement of safety and reliability issues. Also R&D funding has to be increased and joint or risk-sharing programs have to be initiated. What the CAA is asking from manufacturers is a UAV equipped with all the safety features of a manned aircraft. This brings up a lot of technical problems, since this issue has not been considered in the design of most unmanned aircraft. Manufacturers may have to modify their products and in some cases in order to produce a more safe system, they may have to sacrifice some of their aircraft capabilities

Finally, closing this chapter we come to the conclusion that the industry is on the right track for dealing with this problem, but we should have in mind that there is still a lot way to go. Still, a lot of changes have to be made and manufacturers have to collaborate with each other in order to achieve a new trouble-free commercial UAV market. Also government agencies have to be pressured to take a more active part in the development of the industry and must realize that there are a lot of things to be gained from their point of view as well.

C. Cost-effectiveness of UAVs in the civil market

In order to determine whether operating UAVs in the civil industry is a more cost-effective solution than the one offered by manned aircraft, we first have to consider other factors such as the nature, length and complexity of the mission they are asked to undertake.

The fact that the success of UAVs in the market relies heavily on the technological advances related to the industry and the scientific certification of the product, makes the R&D process a vital part of the UAV production. As in many technology-dependent industries, UAV manufacturers are required to buck up their products with strong scientific documentation and an extensive experimental research in order to prove their product's operational capabilities. To do so, a considerable amount of money and attention has to be invested in the area of Research and Development. This is an unpreventable requirement for every company that is aiming to a successful career in the general field of aviation. Looking at the near future of the commercial UAV industry, when the airworthiness and certification issues are resolved, this demand for R&D funding will rise. The manufacturers will have to prove to the CAA that their products are safe, airworthy and also that their manufacturing process can sustain a uniform production. Thus additional costs will emerge in the form of product licensing, testing and quality assurance. To ensure that these changes will be implemented in the most efficient and cost effective way possible, companies will have to expand their R&D operations to the area of production.

One of the biggest cost-raising factors that manufacturers have to deal with in the UAV industry is the purchasing of parts. The small number of suppliers in relation to the manufacturers gives them the opportunity to suppress the market by providing their products at high prices and low variety. Also the fact that most of the UAV suppliers mainly conduct business in the general field of aviation makes them non-dependable on the UAV market, they can thus negotiate with the manufacturers on their own terms. Also, a lot of the sub-assembly parts come from the area of high technology, which makes them expensive to acquire by nature. The reaction of the manufacturers to these problems is to design and manufacture some of the sub-assemblies themselves by using their own resources. However, this solution does not always work since sometimes the reliability and capabilities of the product are depressed. To overcome these problems, the industry should find ways to strengthen the buyer-supplier relations. This could be achieved by the initiation of a supplier's organization whose main aim will be the collaboration between the two parts and the support of the UAV supply chain. Also the information flow between suppliers and buyers needs to be strengthened. The industry should support activities such as UAV exhibitions, conventions and the advertisement of UAV parts/products on the Internet, magazines, and industry publications.

D. UAVs & elimination of risking human lives

It is a fact of life that modern society is no longer companionate to the losses of human lives. Whether or not these losses come from a war or a hazardous accident; the mentality of the global citizen cannot easily accept death in the technologically advanced society that we live in. The aviation industry since the day of its birth, it has been very closely related to

accidents involving human loss. No mater how much money and attention the aviation companies are spending in order to provide a safe flight, accidents will always continue to occur. It is very unlikely even in the future for a 100% safe flight to exist, because factors such as human error and unsafe situations are impossible to be controlled. The elimination of the operator from the cockpit gives UAVs the benefit over manned aircraft that at no time during flight human lives are at stake. This advantage gives them the ability to carry out operations, which their manned competitors are unable to. UAV manufacturers should make use of this driving force in the commercial sector as they have done earlier in the past, in the military industry. In this way the UAV industry can move competition away from the basis of cost-effectiveness. When a mission is considered to be dangerous for the pilot, the issue of cost does no longer exist. The customer is forced to choose the safest solution available no matter how expensive it may be.

In the commercial sector there is a numerous of missions which can be classified as unsafe. These missions are:

1. Surveillance over nuclear reactors.
2. Surveillance over hazardous chemicals.
3. Fire patrol.
4. Volcano patrol.
5. Hurricane observations.
6. Rescue missions over adverse weather conditions.

The inability of manned aircraft to carry out this type of missions has been proven throughout history many times. There have been many examples where survivors from a sea accident were drown just because the aerial rescue operation was delayed in tracking them due to bad weather. In the past, UAVs have been given the opportunity to test their capabilities against operations, which were considered too dangerous by manned aircraft to carry out. For example in 1998 the Aerosonde UAV was given the task to fly around the tropical cyclone Typhoon, located in the western coast of Australia. The mission was completed with success and it was the first time in history where meteorologists had the opportunity to take readings from an aerial platform so close to the cyclone [16].

UAVs have proven to be capable and reliable enough to carry out complicated and challenging operations with success. Also their ability to be expendable in certain missions acts as major advantage in the commercial aviation industry today. UAV manufacturers have to identify these high-risk operations that only their products can undertake, and make them the first priority in their future strategy. In this way UAVs can gain recognition and be the market leaders in a sector, which rightfully belongs to them.

E. Integration of UAV systems

Looking at the evolution of UAV systems throughout their history, we realize that as the years pass by, UAVs are becoming more sophisticated. Today, the industry can provide a wide variety of systems, ranging from aircraft not longer than 15 cm in span, which can enter buildings and retrieve information, to aerial platforms that can fly to the limits of the atmosphere for more than 30 hours. In chapter II, we saw that there are several types and classifications of UAVs in accordance to their capabilities. Not all UAVs are the same, therefore not all of them will be treated equally by the market. It is almost certain that in the near future, some systems will gain recognition and government support in the civil sector, whereas others will have to wait for their turn in the future.

The systems that will most likely attract attention in the near future are the High Altitude Long Endurance (HALE) UAVs, which are by far more technologically advanced than any other UAV system. It is almost certain that these systems will be the first to attain the airworthiness and flight certification license from the CAA and therefore be the first to fully exploit their potentials in the civil market. These systems have gained support from the government of the United States of America over the years, who have invested a lot of money in their R&D. These systems are required to fly at very high altitudes (stratosphere) for more than 24 hours (most of them go up to 40 hours of flight). A flight requirement of longer than 24 hours is chosen due to the fact that the limitations of a human crew in flight are no longer than 24 hours. HALE UAVs such as the Dark Star and the Global Hawk are designed to provide an aerial platform, which can be used for data relay. In other words they are offering a less costly alternative to the expensive services provided by satellites. Market future could reveal a number of UAVs orbiting around the earth's atmosphere transferring data such as telephone, TV, and Internet, in all over the world, very cheaply.

What is interesting about these UAVs, is the fact that two of the biggest ongoing HALE UAV projects (Global Hawk and Dark Star), have been developed by two of the world's larger aviation manufacturers and systems providers: Boeing and Northrop Ghrouman. The fact that these companies have chosen to be actively involved in the UAV industry may be an indication that the future of aviation is directed towards the area of systems integration. Maybe the future challenge of UAVs will be to act as a part of a system comprised by manned aircraft and satellites.

VII. CONCLUSIONS

The Civil UAV industry is a relatively new and unexplored area with little academic literature. There were various difficulties in researching the subject area, as references were rare and hard to find. From the references that existed, some of them were unavailable to the public, whilst others were compiled as industry reports and therefore expensive to obtain.

The most valuable conclusions derived from this project are:

UAV manufacturers have to focus on the advantage of the risk-free operations that their products can perform.
Airworthiness and certification issues for UAV's have to be resolved.
HALE UAV's are expected to meet a lot of attention in the near future.
Most of the civil UAV market developments will be focused in the area of USA and Europe.
Technology will play a key part in the development of the industry in the future.
Industry is currently suppressed by the burgeoning power of the supply chain.
Experience curve effects show us that manufacturing costs are expected to reduce in the future, provided that the airworthiness and certification issues are resolved.

VIII. REFERENCES

[1] Rejesh Kumar, Tactical Reconnaissance: UAVs Versus Manned Aircraft. Air command and staff college, 1997.
[2] M. Lax and B. Shutherland, An Extended Role for Unmanned Aerial Vehicles in the Royal Airforce.
[3] European Unmanned Vehicles Systems Association, Voice of Forum for the Unmanned Vehicles Systems Community. EUROUVS, 1998.
[4] Maj. C. A. Jones, Unmanned Aerial Vehicles an Assessment of Historical Operations and Future Possibilities. Air Command and Staff College, USAF, 1997.
[5] Research Publication, World Markets for Military, Civil and Commercial Unmanned Aerial Vehicles. Frost & Sullivan, 1998.
[6] K. Herrick, Highlights of Trends and Growth in Civil UAV Markets. 1998. (http://www.auvsi.org/auvsicc/faaisg/ppt/markets.htm).
[7] D. Adcock, Marketing Strategies for Competitive Advantage. England, WILEY, 2000.
[8] M. E. Porter, Competitive Strategy. New York, Free Press, 1980.
[9] C. W. Hofer & D. Schendel, Strategy Formulation: Analytical Concepts. USA, West Publishing co, 1978.
[10] M. E. Porter, Please Note Location on Nearest Exit: Exit Barriers and Strategic and Organizational Planning. Harvard Business School Working Paper, 1975.
[11] Lax and Sutherland, Wing Commanders MRB, (), An External Role for Unmanned Aerial Vehicles in the Royal Australian Air Force. RAAF Air Power Studies Center, 1996.
[12] G. W. Goodman, Flying High: Airforce Finally Embraces Unmanned Aerial Vehicles. Armed Forces Journal International, 1995.
[13] Air Chief Marshal Sir Michael, Unmanned Aircraft. Bassey Defense Publishers, 1988.
[14] A. H. Anderson & H. Dobson, Effective Marketing: A Skills and Activity-Based Approach. Oxford, Blackwell Publishers, 1994.
[15] Boston Consulting Group Staff, Perspectives on Experience. The Boston Consulting Group, 1968.
[16] Senator H. I. Mackdonald, An Innovative Robot Aircraft for Atmospheric Monitoring. Parliament house, 1998.